Center Independent Research & Development: GSFC IRAD

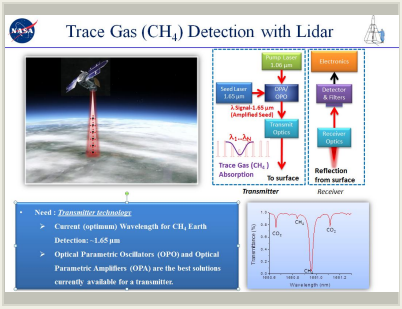
Methane Lidar Transmitter Development for Space

Completed Technology Project (2013 - 2018)

Project Introduction

The objective of this work is to advance the technology readiness level (TRL) of lidar system to enable global Methane (CH_4) and water vapor (H_2O) measurements with sufficient coverage, sensitivity, and precision to address pressing science questions for climate-carbon interaction. Methane (CH_4) is the second most important anthropogenic greenhouse gas with approximately 25 times the radiative forcing of CO_2 per molecule. Natural sources of CH_4 are dominated by wetland emissions in the tropics and Arctic and sub-Arctic boreal regions, with additional contributions from termites, ruminants, ocean biology, and a geological source of unknown significance. Natural sources account for about one-third of the emission total. The wetland source is particularly variable, linked to temperature, precipitation, and surface hydrological changes. Better characterization of the wetland source clearly requires reliable CH_4 measurements in the often-cloudy tropics and over partially inundated land surfaces and open water. Another important science question is in the potential release of large amounts of stored organic carbon as CH_4 and CO_2 from thawing Arctic permafrost soils, which is cause for concern as a rapid, positive greenhouse gas/climate feedback. In addition, large but greatly uncertain amounts of CH_4 are sequestered as gas hydrates in shallow oceans and permafrost soils, which are also subject to potential rapid release. Although these boreal, phase-change driven sources are not yet estimated to be large, their potential magnitude and rapid growth dictate that measurement systems need to be put in place for early detection. Because CH_4 fluxes, as well as chemical loss, are tightly coupled to hydrology, coordinated measurement of both CH_4 and H_2O are highly desired. Precise, seasonal measurements with coverage at high latitudes (i.e., in low sun to dark conditions) are required. Our proposed laser remote sensing technology will be a key step in fostering measurements of CH_4 and H_2O with sufficient coverage, sampling, and precision to address major science questions.

Our proposed laser remote sensing technology will be a key step in fostering measurements of CH_4 and H_2O with sufficient coverage, sampling, and precision to address these and other science issues. The benefit to future Earth Science missions is that the proposed technology enables global CH_4 measurements to be made where they are really needed: in the absence of sunlight (i.e., at night and at high latitudes in all seasons), in the presence of scattered or optically thin clouds and aerosols, over land and water surfaces, and with higher accuracy and precision than currently available. These qualities are precisely those that make the corresponding H_2O measurements a valuable addition to the current operational suite for weather and climate analysis. The measurements will help satisfy the critical scientific need to understand the behavior of greenhouse gases as they contribute to climate change as well as to meet pressing national needs for development of a national carbon monitoring system serving science, policy-makers, and stakeholders.



Airborne Lidar for Methane Measurements Project (CH4 LIDAR)

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The end goal of the project would be to demonstrate the readiness of the a CH_4 trace gas lidar instrument for space flight. The target wavelengths and energies are ~1.65 µm and energy is ~500 µJ. The specific objectives of this project are to:

1. Improve the tunability architecture of the seed laser(s) using two different designs.
    1. The first design uses a DBR laser at 1651 nm to be delivered under an STMD Game Changing Technology program.
    2. The second design uses a novel approach: single or dual sideband (SSB/DSB) tuning. It has the potential to significantly simplify the seed laser design and uses existing DFB lasers.
2. Demonstrate 500 µJ in Er:YGG/Er:YAG with narrow linewidth.
3. Reduce the size and complexity of the existing OPO
4. Use the tunable seed from objective 1 with the OPO and Er:YAG from objectives 2 and 3 to demonstrate open path CH_4 measurements and correlate them with an in-situ calibrated instrument (Picarro in-situ CH_4 analyzer).

Anticipated Benefits

Orbital or sub-orbital Earth Venture missions or a future ASCENDS mission to measure greehouse gas mixing ratios in the atmosphere.

Space flight laser technology development

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:

Peter M Hughes

Project Managers:

Matthew J Mcgill
William E Cutlip

Principal Investigator:

Haris Riris

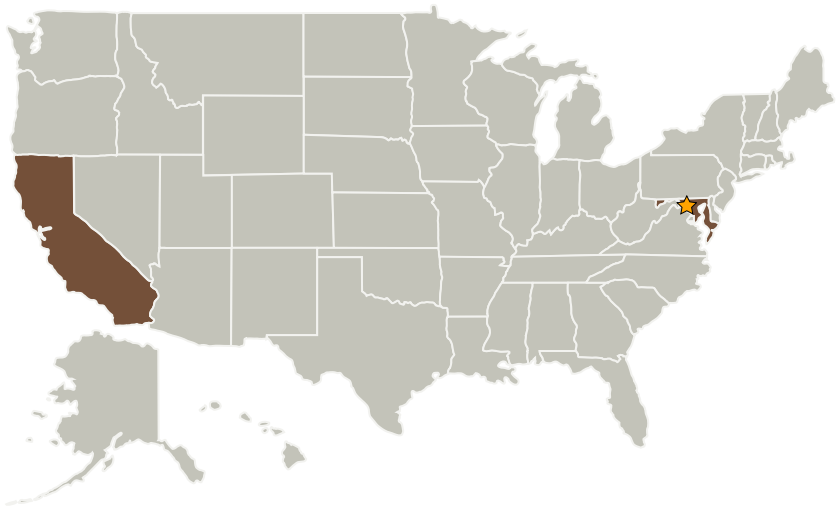
Co-Investigators:

Kenji Numata
Stewart T Wu

Methane Lidar Transmitter Development for Space

Completed Technology Project (2013 - 2018)

Primary U.S. Work Locations and Key Partners



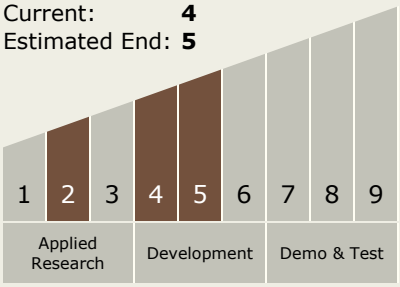
Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Co-Funding Partners	Type	Location
Space Technology Mission Directorate(STMD)	NASA Mission Directorate	

Primary U.S. Work Locations	
California	Maryland

Technology Maturity (TRL)

Start: **2**
Current: **4**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.5 Lasers

Target Destinations

Earth, Mars, Others Inside the Solar System

Supported Mission Type

Projected Mission (Pull)

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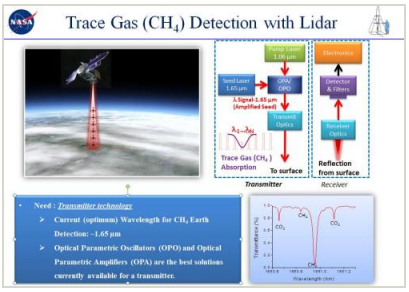
Images



Airborne Lidar for Methane Measurements Project (CH4 LIDAR)
Airborne Lidar for Methane Measurements Project (CH4 LIDAR)
(https://techport.nasa.gov/image/4075)

Links

Airborne measurements of atmospheric methane column abundance using a pulsed integrated-path differential absorption lidar
(http://www.opticsinfobase.org/ao/fulltext.cfm?uri=ao-51-34-8296&id=246472)

Fast-switching methane lidar transmitter based on a seeded optical parametric oscillator
(http://link.springer.com/article/10.1007%2Fs00340-014-5783-4#/page-1)

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(http://link.springer.com/article/10.1007%2Fs00340-014-5783-4)

GSC-17281-1
(https://ntts.arc.nasa.gov/app/)

Optical Parametric Technology for Methane Measurements
(http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=2436042)

Project Website:

http://sciences.gsfc.nasa.gov/sed/